CLOUD-BASED APPROACH FOR REAL-TIME MONITORING OF SMART GRID TOPOLOGY

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Abstract

This article proposes a real-time communication system for monitoring of Smart Grid (SG) topology using Cloud-based approach. Tracking of SG topology in real-time is achieved using available local measurements from smart devices and Cloud-based control center communicating through the internet. IEEE 34-bus test grid is modeled using MATLAB/Simulink software package to support real-time communication with open source IoT platform ThingSpeak. Load balancing, voltage regulation and fault management functions are simulated to show capabilities of the proposed Cloud-based monitoring approach.

Introduction

Network topology processing is the first step in the state estimation of SG. State estimation algorithms use network topology data, power system elements data, available measurements, and pseudo-measurements [1]. During topology processing, the statuses of breakers/switches are first telemetered by the system network configurator [2] and then processed using a bus-section/switching-device network model [3]. Monitoring of network topology enables up to date information related to feeder reconfiguration (FRC) in distribution networks. FRC is a planning and real-time operational control process that changes the distribution network topology [4]. Cloud-based communication approach could be an efficient and a low cost solution for monitoring of SG topology. Traditionally, processing, analyzing, and storing data from large-scale distributed system, such as SG, are handled by the Cloud architecture [5].

Cloud-based communication approach for monitoring of SG topology

The application of the proposed approach is described using the example of a well-known IEEE 34-bus test grid case study.
SG operating center is using Cloud-based IoT server for collecting and analyzing information on statuses of switching devices, thus continuously monitoring SG topology. Every switching device status change is captured in near real-time.

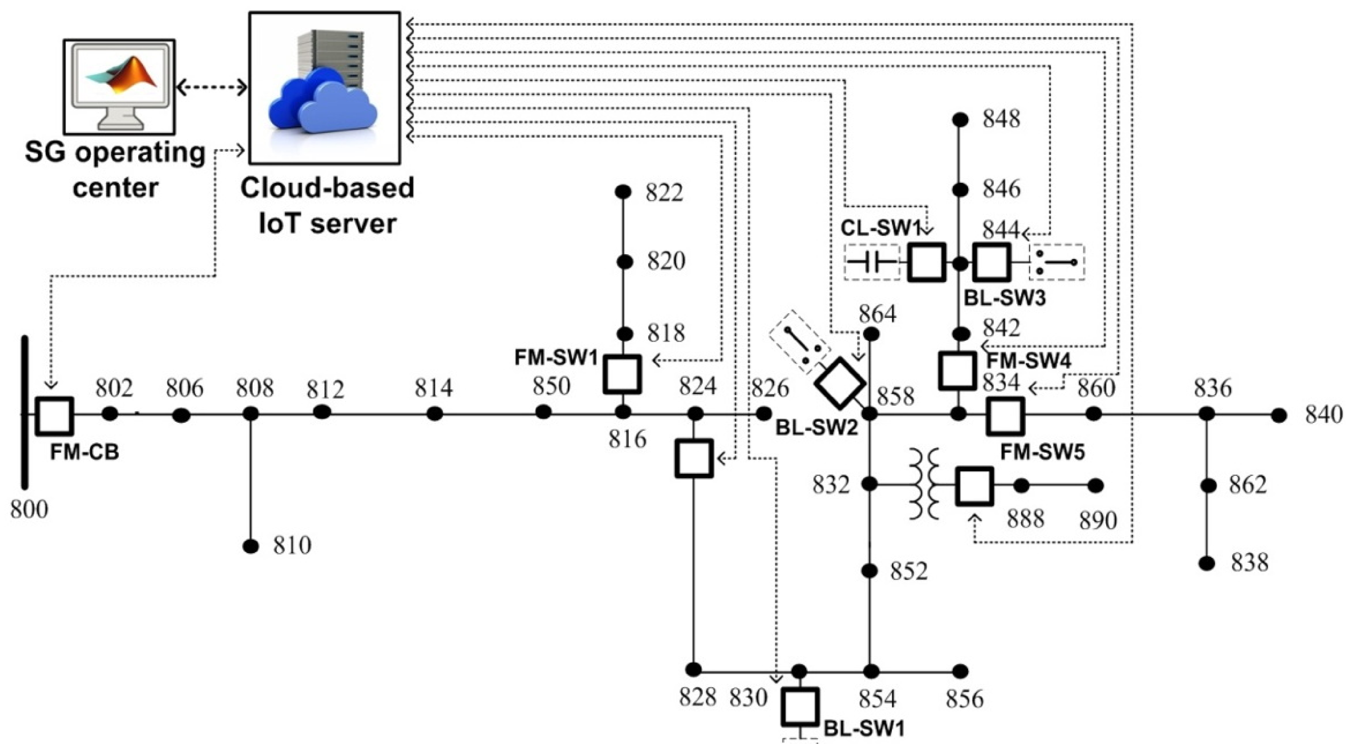

Figure 1: Cloud-based communication approach for monitoring of SG topology – IEEE 34-bus test grid case study

Switches can be classified in three categories: load balancing (BL-SW1, BL-SW2 and BL-SW3), voltage regulation (CL-SW1) and fault management system (FM-CB, FM-SW1, FM-SW4, FM-SW5 and two remaining unnamed switches).

Modeling and simulation setup

- A new Simulink-based IEEE 34-bus test grid model is developed by using existing example of IEEE 13-bus test grid model embedded in MATLAB [6]. Detailed information on IEEE 34-bus test grid is available in [7].
- We use communication model, which enables real-time data transfer between MATLAB/Simulink and ThingSpeak IoT platform. [8]. Model communicates with ThingSpeak server by using standard TCP/IP.

Simulation results and disscusion

Load balancing

Figure 2: Real-time monitoring of IEEE 34-bus test grid topology – load balancing case study

The first switch BL-SW1 operates 20 s after simulation start, the second BL-SW2 follows at 40 s and the third one BL-SW3 operates at 80 s.

Voltage regulation

- In this case study it is assumed that initially there is no capacitive load in test grid.
- 20 s after the simulation start switch CL-SW1 operates and connects capacitive load to bus 844 (Fig.1).
- The switch operation is successfully detected in time interval 20-40 s by the monitoring function, as it is shown in Fig.3.
- The magnitudes of phase voltages at bus 802 are given in Fig.4.

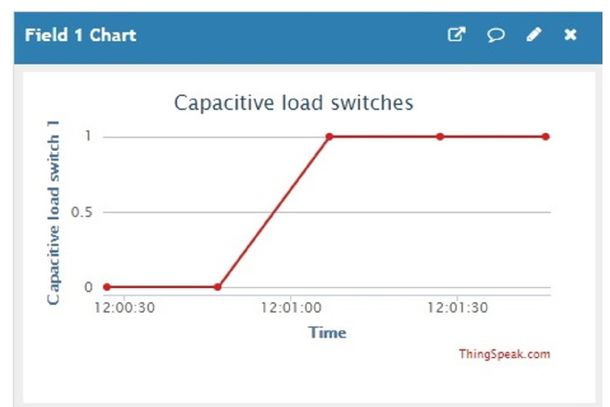

Figure 3: Real-time monitoring of IEEE 34-bus test grid topology – voltage regulation case study

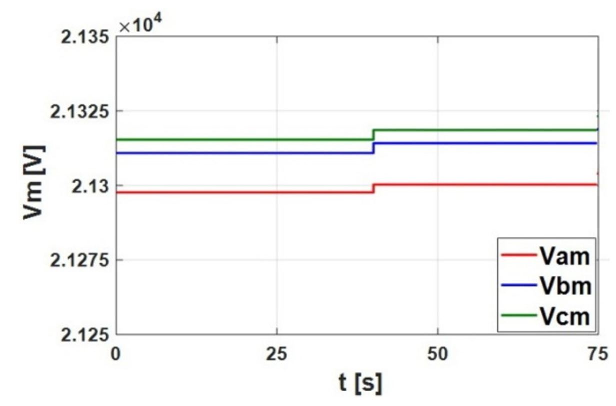

Figure 4: Voltage magnitude changes at bus 802 - voltage regulation case study

Fault management system

The following sequence of switching events happened: (1) the main breaker FM-CB initially disconnected feeder and interrupted the fault current at time t2 = 40 s; (2) the switch FM-SW1 disconnected the lateral from the bus 816 at time t3 = 45 s; (3) FM-CB reconnected and immediately again disconnected the feeder, since the fault is not cleared - (t4 = 70-71 s); (4) FM-SW1 reconnected the lateral at time t5 = 75 s; (5) FM-SW4 disconnected the lateral from the bus 834 at time t6 = 75 s; (6) FM-CB reconnected and immediately again disconnected the feeder, since the fault is not cleared - (t7 = 100-101 s); (7) FM-SW4 reconnected the lateral at time t8 = 105 (8) FM-SW5 disconnected the feeder's section from the bus 834 at time t9 = 105 s; (9) FM-CB permanently reconnected the feeder at time t10 = 130 s, since the fault is now cleared. This is shown on Fig.5. FM-CB operation status is shown in field 1 chart, while statuses of FM-SW1, FM-SW4 and FM-SW5 are shown in fields 2, 5 and 6 charts, respectively.

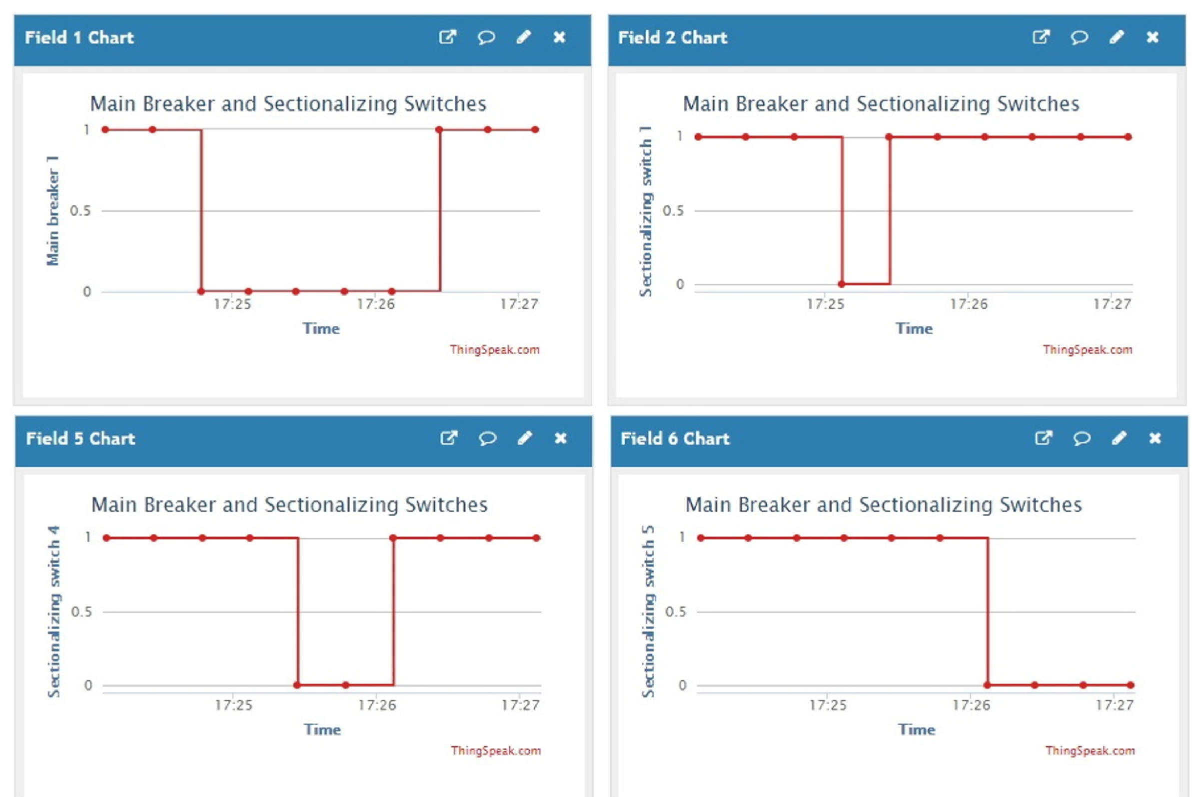

Figure 5: Real-time monitoring of IEEE 34-bus test grid topology – fault management system case study

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